Industry Description and Practices

This document addresses the formulation of pesticides from active ingredients. Manufacture of pesticides is the subject of another guideline. Major chemical groups that are formulated include:

- Insecticides (organophosphates, carbamates, organochlorines, pyrethroids, bio-rationals, and botanicals).
- Fungicides (dithiocarbamates, triazoles, MBCs, morpholines, pyrimidines, phthalamides, and inorganics).
- Herbicides (triazines, carbamates, phenyl ureas, phenoxy acids, bipyridyls, glyphosates, sulfonyle ureas, amida xylenols, and imidazole inones).
- Rodenticides (coumarins).

The main purpose of pesticide formulation is to manufacture a product which has optimum biological efficiency, is convenient to use, and minimizes environmental impacts. Active ingredients are mixed with solvents, adjuvants (booster), and fillers as necessary to achieve the desired formulation. The types of formulations include: (a) wettable powders; (b) soluble concentrates; (c) emulsion concentrates; (d) oil-in-water emulsions; (e) suspension concentrates; (f) suspoemulsions; (g) water dispersible granules; (h) dry granules; and (i) controlled release (the active ingredient is released from a polymeric carrier, binder, absorbent, or encapsulant at a slow and effective rate into the environment). The formulation steps may generate air emissions, liquid effluents, and solid wastes.

Waste Characteristics

The principal air pollutants are particulate matter and volatile organic compounds (VOCs). These are released from mixing and coating operations.

Most liquid effluents will result from spills, the cleaning of equipment, and process wastewaters. The effluents may contain toxic organics including pesticide residues. Major solid wastes of concern include contaminated discarded packaging and process residues. There will also be effluent treatment sludges. Solid wastes generated depends on the process and can be about 3.3 grams per kilogram (g/kg) of product and may contain 40 percent active ingredient.

Pollution Prevention and Control

The recommended pollution prevention measures are:

- Use equipment washdown waters as make-up solutions for subsequent batches.
- Use dedicated dust collectors to recycle recovered materials.
- Use suction hoods to collect vapors and other fugitive emissions.
- Return toxic materials packaging to the supplier for reuse.
- Find productive uses for off-specification products to avoid disposal problems.
- Minimize raw material and product inventory to avoid degradation and wastage.
- Label and store toxic and hazardous materials in secure bunded areas.
A pesticide formulation plant should prepare and implement an Emergency Preparedness and Response Plan which takes into account neighboring land uses and the potential consequences of an emergency or accidental release of harmful substance. Measures to avoid the release of harmful substances should be incorporated in the design, operation, maintenance, and management of the plant. Additional guidance on the selection and use of pesticides is provided in Guidelines and Best Practice GB 4.03 “Agricultural Pest Management” (World Bank 1993).

**Treatment Technologies**

Baghouses for particulate matter (PM) removal and carbon adsorption for removal of VOCs are applicable and effective technologies. Reverse osmosis or ultra-filtration is used to recover process materials from wastewater. Effluent treatment may include carbon adsorption, detoxification of pesticides by oxidation (using ultraviolet systems or peroxide solutions), and biological treatment. Exhausted carbon from absorption processes may be sent for regeneration or combustion.

Due to the relatively small volumes of solid wastes, it is difficult to find acceptable and affordable methods of disposal. Ideally, solid wastes should be sent for incineration where combustion conditions (such as 1100 °C and at least 0.5 second flame residence time) are maintained to ensure effective destruction of toxics.

**Emissions Guidelines**

Emission levels for the design and operation of each project must be established through the Environmental Assessment (EA) process, based on country legislation and the Pollution Prevention and Abatement Handbook as applied to local conditions. The emission levels selected must be justified in the EA and acceptable to the World Bank Group.

The following guidelines present emission levels normally acceptable to the World Bank Group in making decisions regarding provision of World Bank Group assistance; any deviations from these levels must be described in the World Bank Group project documentation.

The guidelines are expressed as concentrations to facilitate monitoring. Dilution of air emissions or effluents to achieve these guidelines is unacceptable.

All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.

**Air Emissions**

The following emissions levels should be achieved:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milligrams per normal cubic meter (mg/Nm³)</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>20 and 5*</td>
</tr>
<tr>
<td>VOCs</td>
<td>20</td>
</tr>
<tr>
<td>Chlorine (or chloride)</td>
<td>5</td>
</tr>
</tbody>
</table>

* Where very toxic compounds are present (Refer to WHO’s list of extremely hazardous substances).

**Liquid Effluents**

The following effluent levels should be achieved:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>milligrams per liter (mg/L)</td>
</tr>
<tr>
<td>PH</td>
<td>6-9</td>
</tr>
<tr>
<td>Absorbable organic chlorine (AOX)</td>
<td>1</td>
</tr>
<tr>
<td>Chemical oxygen demand (COD)</td>
<td>150</td>
</tr>
<tr>
<td>Total suspended solids*</td>
<td>20</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>10</td>
</tr>
<tr>
<td>Organochlorines</td>
<td>0.05</td>
</tr>
<tr>
<td>Nitro-organics</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Pyrethroids 0.05
Phenoxy compounds 0.05
Active ingredients (each) 0.05
Arsenic and hexavalent chrome (each) 0.1
Copper 0.5
Mercury 0.01

* Monthly average but in no case more than 50 mg/L

Note: Effluent requirements are for direct discharge to surface waters.

**Solid Wastes**

Toxic solid wastes should be treated to destroy toxic organics to levels below 0.05 milligrams per kilograms (mg/kg).

**Ambient Noise**

Noise abatement measures should achieve either the following levels or a maximum increase in background levels of 3 dB(A). Measurements are to be taken at noise receptors located outside the project property boundary.

<table>
<thead>
<tr>
<th>Receptor</th>
<th>Daytime</th>
<th>Nighttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential; institutional; educational</td>
<td>55</td>
<td>45</td>
</tr>
<tr>
<td>Industrial; commercial</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>

*Ambient Noise*

The emission requirements given here can be consistently achieved by well-designed, well-operated and well-maintained pollution control systems.

**Monitoring and Reporting**

Frequent sampling may be required during start-up and upset conditions. Once a record of consistent performance has been established, sampling for the parameters listed above should be as detailed below:

- Continuously monitor air emissions exiting the air pollution control system where toxic organics are being emitted at rates greater than 0.5 kilograms per hour (kg/h).
- Analyze liquid effluents generated from the process before discharge (or at least once per shift). In cases where they are suspected to be toxic, bioassay test should be performed to assess its acceptability in the environment. (Toxicity factor for fish should not be greater than 2; Toxicity to Daphnia, TD=8; Toxicity to Algae, TA=16; and Toxicity to Bacteria=8.)

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. These should be reported to the responsible authorities and relevant parties, as required, and provided to MIGA if requested.

**Key Issues**

The following box summarizes the key production and control practices that will lead to compliance with emission guidelines:

- Good management practices, especially cleanliness and materials control, are essential and must be put in place.
- Return packaging for refilling.
- Incinerate all toxic organic wastes (except those containing toxic volatile metals).

**Further Information**

The following are suggested as sources of additional information (these sources are provided for guidance and are not intended to be comprehensive):


